

# Joint Planning and Development Office Targeted NextGen Capabilities for 2025

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Joint Planning and Development Office

NextGen

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## 1. Introduction

Under Vision 100 – Century of Aviation Reauthorization Act (P.L. 108-176), the Joint Planning and Development Office (JPDO) was charged with creating an integrated plan for the Next Generation Air Transportation System (NextGen). The focus of the legislative mandate was to leverage existing technologies and align the research and development (R&D) needed to transform our nation's air transportation system. In this context, the JPDO was established to manage the public and private collaborative work related to NextGen. The JPDO coordinates the NextGen efforts of the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the Departments of Transportation (DOT), Defense (DOD), Commerce (DOC), and Homeland Security (DHS), and the White House Office of Science and Technology Policy (OSTP). The JPDO also has access to subject matter expertise from industry and academia through the NextGen Institute.

The purpose of this document is to focus research and system implementation investment decisions by identifying the NextGen elements that can be achieved by 2025. These elements will need to be consistent with available resources, national priorities, and technology developments. This document also provides a baseline for the JPDO to engage its industry, labor, academia, and government partners in defining the goals and targets of performance metrics as a way of refining research priorities. In addition, it provides a basis to update JPDO planning tools, namely the NextGen Concept of Operations (ConOps), the Enterprise Architecture (EA), and the Integrated Work Plan (IWP). These planning tools are used to articulate the NextGen vision and coordinate its supporting efforts. Ultimately, this document was created to involve the NextGen community in maturing our collective understanding of 2025 and beyond, and is part of an ongoing vetting process to clarify the NextGen vision.

This document presents NextGen capabilities and their deployment in the 2025 timeframe, based on the JPDO and its partner agencies' modeling, financial analysis, and studies. These targeted 2025 capabilities, which build on near- and mid-term (through 2018) systems being developed by the FAA and other government partners, will provide the improvements in performance and capacity of the National Airspace System (NAS) necessary to meet 2025 requirements. Achieving this level of capability by 2025 assumes successful R&D outcomes from many of the advanced concepts, as well as timely resolution of significant policy issues and challenges. The JPDO's multi-agency influence and strong engagement with industry are critical to the success of these initiatives.

### Targeted Capabilities for 2025

- Net-Centric Operations
- Trajectory Based Operations
- DataComm
- Improved Surface Operations
- Airspace Redesign
- RNAV/RNP
- ADS-B
- CATM
- On-Demand NAS Information
- Time-Based Flow Management
- Separation Management
- Merging and Spacing
- UAS Operations
- GPS
- Reduced Weather Impact
- Layered Adaptive Security

## 2. Targeted System Description

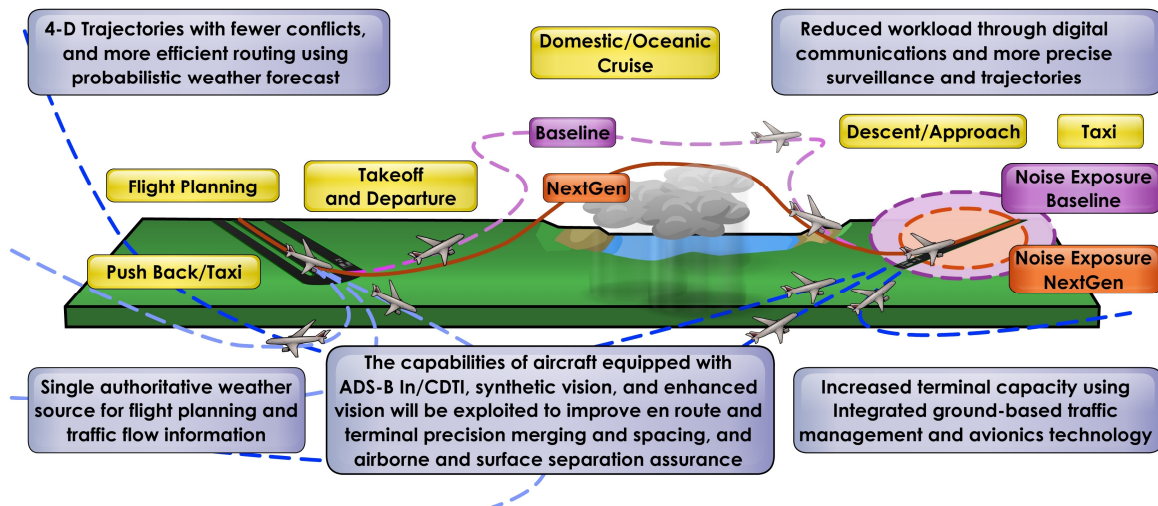
### 2.1 System Overview

This section explains how new capabilities will be used during flight operations in 2025 and how they will be enhanced by cross-cutting activities, such as net-centric operations, security, planning, airports, and flight operations. This provides a context for the subsequent “Challenges in Realizing 2025 Targeted Capabilities” section. The examples cited are not intended to cover every aircraft and every flight. In some instances, the available capabilities for 2025 will not be implemented in whole until sometime after 2025.

This view of 2025 is also based on the premise that NextGen partners will successfully execute their NextGen responsibilities. The major difference between the FAA’s mid-term implementation and NextGen 2025 is that NextGen 2025 is a stronger, more dynamic flow management system, coupled with data communications and integrated with ground automation to enable complex clearances. While there will not be any major changes to the roles and responsibilities of pilots and controllers, they will have new tools at their disposal. Merging and spacing will remain a controller separation function, but controllers will be able to give aircraft new clearances – instructing them to stay behind other aircraft by a certain distance or time or to merge behind preceding aircraft – enabled by Automatic Dependent Surveillance-Broadcast (ADS-B) In. In today’s system, aircraft have delegated responsibility for separation in visual conditions. In 2025, NextGen will permit delegated responsibility for separation in instrument conditions because the pilot will have the capability to “see” the preceding aircraft using cockpit display of traffic information (CDTI), rather than relying solely on their own vision.

The operational descriptions that follow trace the phases of a typical flight operating in NextGen (as illustrated in Figure 1). These descriptions also describe some of the key capabilities that will enhance airspace safety, security, efficiency, and environmental compatibility.





**Figure 1. NextGen 2025 Flight Profile**

## 2.2 NextGen Capabilities by Flight Segment

### 2.2.1 Flight Planning

Flight planning in 2025 will greatly improve as the result of more complete and accurate information. With the current system, flight planners have limited insight into the status of the NAS and how it might affect a flight plan. For example, the current system provides information on the effects of ground delays, and there is some ability for users to negotiate with the Air Navigation Service Provider (ANSP) – in this case the FAA Air Traffic Organization (ATO) – to select which of their flights would be delayed to balance demand and available resources.

In the future, with the implementation of widespread net-centric operations, four-dimensional (4-D) weather products, and dynamic, system-wide traffic flow-management tools, the airspace user will be involved in even more collaborative decision making with more up-to-date information on the status of NAS resources. This will include runway closures, airspace closures due to Special Activity Airspace (SAA) or other constraints, and airspace demand and capacity information, which will increase situational awareness on all filed flight plans. As a result, flight plans will be more accurate and up-to-date in terms of weather information and projected demand, and will also be integrated into NAS automation tools, which will increase predictability.

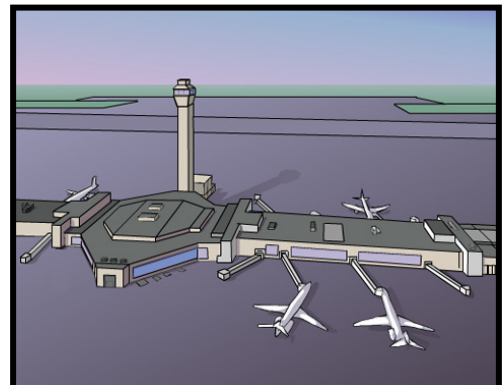
The targeted capabilities include the introduction of trajectory-based operations (TBO) for high-density airspace with full implementation occurring beyond 2025. With TBO, users will be able to query the system using their proposed alternative flight plans to determine the most optimal plan for their flight. Thus, a user could

enter several trial flight plans for a particular flight until one is mutually agreed upon with the ANSP. This interaction, along with improved NAS status information and projections, will improve flight profiles and reduce fuel use and delay through shorter and more wind- and weather-efficient routings. TBO will also improve the ability of the NAS to accommodate a greater variety of vehicle types, such as Unmanned Aircraft Systems (UAS) and Vertical Take-Off and Landing aircraft (VTOL), which are important to DOD, DHS, and DOC operations. Net-centric flight planning and operations, which track aircraft ID, will give military and law enforcement operations more timely information in order to rapidly identify and respond to errant aircraft.

### **2.2.2 Push Back and Taxi**

The 2025 surface traffic management system will better integrate arrivals, departures, and surface operations to ensure efficient traffic flow and improve the safety of airport operations. Once the flight plan is filed and accepted by the ANSP, the pilot of an appropriately equipped aircraft can request and receive an electronic pushback clearance from air traffic control (ATC) via digital data communications. If the weather at the airport surface, around the airport, en route, or at the destination airport has changed since the flight plan was filed, data communications will enable the pilot or airline operations center (AOC) to modify the flight plan before pushback, allowing the modified flight plan to be transmitted to the ANSP for approval and delivered electronically to the aircraft. Similarly, if airspace constraints require a pre-departure route change for a flight, the ANSP will use alternatives that have been pre-coordinated with the AOC or flight operations center (FOC) based on its priorities and constraints, and deliver the route amendment electronically to the aircraft and the AOC. Automation and data communications will substantially reduce today's requirement for extensive pilot and controller verbal negotiations to update a flight plan and departure time, as well as the potential for communication errors and misunderstandings.

Today's system offers a limited number of tools to efficiently manage traffic on the airport surface. For example, most clearances are provided by voice. By 2025, improved tools for integrated surface traffic management will efficiently sequence the departures and movement of arrivals to minimize taxi time, thereby reducing delay, noise, fuel burn, and emissions. Once the electronic pushback clearance and taxi path is sent to the aircraft, the pilot will electronically confirm and execute the action. From pushback to takeoff, most clearances and confirmations will be transmitted through data communications. Surface information displays will reduce runway incursions by providing pilots, controllers, and ground equipment operators with improved situational awareness (particularly during low visibility



operations), while surface traffic management tools will address special conditions, such as low visibility operations, deicing, and runway closures. Aircraft equipage will include moving maps, ADS-B In with CDTI, synthetic vision, and possibly enhanced vision to support safe taxi-out and taxi-in operations in most meteorological conditions. Synthetic vision requires the high-accuracy Global Positioning System (GPS) data provided by the Ground-Based Augmentation System (GBAS).

### **2.2.3 Takeoff and Departure**

More efficient departure sequencing and metering of flights will reduce delay and fuel burn. Approved flight plans will include initial optimal climb altitude and heading, minimizing level-offs. Wake vortex behavior prediction tools will increase capacity by allowing reductions in arrival and departure separations and by enabling increased operations on closely-spaced parallel runways. Redesigned airspace will permit increased throughput by allowing a greater use of Area Navigation (RNAV) and Required Navigation Performance (RNP) procedures, improving transition airspace efficiency. Extended terminal procedure geographical ranges and reduced separation standards will allow for greater flexibility in integrating arrival and departure traffic, especially during weather constraints or other disruptions to normal flows. Selected routes will be bi-directional (used for either arrival or departure) depending on the traffic and the location of severe weather.

### **2.2.4 Domestic and Oceanic Cruise**

In 2025, before flights enter en route airspace and during routine en route flight, changes in frequency and barometric pressure, as well as route clearance and altitude changes, will be provided to the pilot via data communication rather than voice. Reducing the number of voice communications increases the controller's efficiency and ability to manage more traffic, and it also reduces pilot workload. The high accuracy of ADS-B and the ability to fly more precise flight trajectories will result in fewer conflicts. With fewer conflicts, flight trajectories can conform closer to the profile filed in the flight plan. The combination of ADS-B Out as the primary means of surveillance, better conflict detection, and multi-sector flow management with improved metering will also increase the capacity of en route airspace by reducing separation minima. Additionally, optimized procedures will allow increased, user-preferred oceanic flight profiles with fewer altitude change restrictions through reduced aircraft-to-aircraft spacing between aircraft equipped with enhanced communication, surveillance, and flight deck avionics. ADS-B In will be used to support tactical maneuvers in oceanic airspace.

In the event of a detected conflict between aircraft or with weather, automated conflict resolution will provide the controller with a safe and fuel-efficient resolution. Once the proposed resolution is selected, data communications will provide updated information or clearances to the pilot. The capability to auto-



load flight plan changes directly into the flight management system (FMS) will reduce pilot workload, as well as the potential for miscommunication or entry error. Airborne decision support tools using ADS-B In may complement ground-based conflict detection and resolution.

Another major change will be to create a seamless interaction between the traffic flow management system and air traffic control, resulting in a more unified Air Traffic Management system. If, for example, problematic weather does not materialize, the system restricts capacity and creates unnecessary delays. In the 2025 system, a multi-stage decision process along each phase of flight will minimize ground delay and enable travel on an optimal path based on the most up-to-date information available. The automation system will assign probabilities to future weather and projected demand in each airspace sector. Sophisticated programs that address uncertainty in decision making will use these probabilities and other data on NAS status to help determine the safest and most efficient way to avoid the weather and refine decisions as the flight progresses.

### **2.2.5 Descent and Approach**

More accurate time of arrival, with variances of only a few seconds, will allow delegated interval management using time-based airborne merging and spacing enabled by ADS-B In. RNP will allow additional flights in the terminal area, expand the use of optimal profile descents, increase terminal airspace capacity, and, in many cases, efficient runway use. Using these capabilities, on-board automation will deliver the aircraft with improved accuracy to successive arrival metering points along its flight plan trajectory within a minute's accuracy.

Terminal area operations will begin at an arrival meter point located in the extended terminal area, approximately 120 nautical miles (nm) from the runway threshold. Sequencing and separation of flights will be managed by an integrated air/ground strategic automation, while trajectory changes that are necessary to meet time-of-arrival requirements will be transmitted by data communications. The top-of-descent point will be chosen to match the aircraft's flight characteristics to an optimal profile descent.

On-board interval management will offer a number of benefits. Controller workload will be reduced as a result of pilots having the responsibility for separation associated with approaches in Instrument Meteorological Conditions (IMC) and being capable of spacing behind another aircraft. The ability to use optimal profile descents will increase without violating separation on final approach. But the major benefit is that spacing precision will dramatically improve, taking advantage of maximum surface safety capacity and allowing more aircraft to land during a given period of time. Because the pilot will be using CDTI and ADS-B In, it will also permit visual approach procedures in IMC.

With improved situational awareness and weather information, appropriately equipped general aviation (GA) aircraft operating at local airports within dense metroplex areas will benefit from strategic and tactical adjustments to the metroplex traffic. GA aircraft will also avoid delays induced by controller workload during periods of peak demand. Net-centric information will enable remotely staffed towers at GA airports, which will enhance taxiway, runway, and local airspace management, as well as safety and security.

Synthetic vision (database driven) and enhanced vision (sensor driven) system technologies will allow arrivals and departures in low-visibility conditions, and could support curved approaches at airports that occasionally are required to use reduced-capacity configurations due to airspace or terrain restrictions. Curved approaches enable additional arrivals at airports that would otherwise be capacity limited. Synthetic vision will also enable visual condition-like approaches to terrain-constrained airports in all meteorological conditions, and enhanced vision equipment will verify synthetic vision data and support avoidance of traffic, terrain, and local obstacles. Business aircraft equipped with these systems will benefit from increased access to regional airports, while low-end GA aircraft's safety and utility will improve due to better situational awareness in challenging terrain and adverse weather conditions.

### **2.2.6 Taxi**

After landing, an aircraft will take the most efficient runway exit. The integrated surface traffic automation system will generate a conflict-free path and the controller will electronically send the taxi path to the aircraft via data communications. The pilot will accept the path and load it into the airport moving map display, providing improved situational awareness of its position and of other aircraft, reducing taxi time to the gate, fuel burn, emissions, and the potential for runway incursions.

### **2.2.7 Proactive Approach to Safety Management**

Safety in 2025 will be augmented by a national-level integrated aviation safety management framework. This will be achieved by the implementation of a Safety Management System (SMS) throughout all facets of the air transportation system. As part of the SMS, organizations, agencies, and departments will have a safety improvement culture where aviation safety and its continuous improvement are seen as the primary goals, and safety design assurance will have been built into all operations under NextGen. In 2025, safety concerns will be identified and resolved before they occur, through an ongoing integrated operational data collection, management, and analysis capability. Safety research efforts will be coordinated and determined through a national aviation safety strategic plan.

## **2.3 Cross-cutting and Enabling Functions**

### **2.3.1 Deployment**

The capabilities described in the preceding narrative are not expected to be available for all aircraft in all airspace at all times in 2025. However, systems will be deployed to ensure that the most critical airspace limitations are addressed to achieve desired levels of capacity and reduce delay. It is expected that most scheduled flights will have mixed equipage for more efficient TBO, and the busiest 35 major airports will have the surface and air traffic management automation necessary for those operations. This will extend the operational capacity of highly congested airports and metroplexes. Most aircraft operating in high altitude airspace, including those operating under instrument flight rules (IFR), will be equipped with data communications, and will continuously transmit position (ADS-B Out), enabling accurate ground-based surveillance and aircraft-based ADS-B In applications. Traffic flow management automation systems compatible with TBO will be available nationwide, and ATC automation systems, including the En Route Automation Modernization (ERAM) system, will be able to process ADS-B information. There will be complementary deployments for the carriers and the AOC/FOCs.



These features will be implemented according to cost-effective deployment schedules matching the needs to accommodate traffic growth, reduce delay, protect the environment, and enhance safety. Beyond 2025, the implementation of these and other NextGen capabilities will continue to expand, keeping pace with growth, until all of the capabilities envisioned for NextGen are achieved. The capabilities beyond those targeted for 2025 will require increased levels of automation and integration as the systems are deployed to more facilities and adopted by more users. To meet these challenges, it is expected that NASA and other government partners will continue to perform research and development and transfer the resulting technology to provide the capabilities for 2025, as well as for the more advanced systems that will be needed to achieve the full NextGen vision.

The infrastructures planned to be in place by the end of the mid-term (2018) timeframe, along with the demonstration of key capabilities (and their operation at selected sites) described in the FAA's *NextGen Implementation Plan* (NGIP) are essential to providing the foundation needed for NextGen 2025.

By building on that foundation, the targeted Operational Improvements (OIs) envisioned for 2025 will provide the capabilities needed in that timeframe, although some advanced NextGen capabilities will not be available until later. Appendix A, "Targeted Operation Improvements for 2025", lists the OIs expected

by 2025, while Appendix B, “Operational Improvements Expected Beyond 2025”, identifies key advanced OIs that will occur later. These OIs will require additional changes in roles and responsibilities between controllers and pilots, new and upgraded infrastructure/equipment, implementation of automated negotiation and separation management, and gate-to-gate TBO.

### 2.3.2 Layered Adaptive Security

Operating and security information must be shared in a secure and timely manner among system participants, including air traffic facilities, airlines, airports, and security authorities, and, where appropriate, passengers and shippers.

NextGen 2025’s layered adaptive security is a risk-managed system that will depend on multiple technologies, policies, and procedures, scaled to defeat a given threat or threat category. This adaptability will further permit the use of increased variability in security system operations, and will create more uncertainty for an adversary. Adversaries will not be able to defeat one particular security measure and thereby achieve a “breakthrough” to operate freely with no further barriers to their activities. These systems will adapt to scale their resources, systems, and procedures to the risk level of a threat in a given situation, rather than being bound to an inflexible, “one size fits all” approach.

### 2.3.3 Net-Centric Operations

NextGen will require complex, fast-paced decision making based on timely, accurate, and comprehensive information (Figure 2). Almost every significant decision and its execution will require cooperation and coordination among multiple, geographically dispersed participants, using a family of systems operated by the NextGen government partners and air transportation service providers.

A net-centric NextGen, with rapid machine-to-machine information exchanges, will support advanced automation tools and improve situational awareness through aggregated data from weather, NAS status, and passive and active surveillance systems, such as ADS-B (both In and Out). Flight crews and controllers will collaborate to dynamically adjust airborne and pre-departure trajectories in response to projected and real-time constraints.



**Figure 2. Net-Centric Operations in NextGen**

Net-centric operations will be achieved by the incremental implementation of a secure, trusted flow of information over legacy and new infrastructures such as System Wide Information Management (SWIM) and Aircraft Access to Swim (AAtS). These infrastructures will be developed, fielded, and maintained by both the government partners and private-sector stakeholders. Net-centric information exchange and infrastructure services will use Internet technologies and other network protocols to distribute information throughout the system. Information producers will publish their information for access by authorized consumers to get what they need, when they need it. Policies, protocols, and system safeguards will be in place to ensure that data is only shared with users that have a legitimate right to the information. The segregated enterprises belonging to NextGen stakeholders will be linked into an “enterprise of enterprises,” providing common shared information.

Net-centric tools and applications will allow authorized personnel to access required information from any location with a secure Internet connection. Pilots of e-enabled aircraft will be able to download trajectory data—optimized by up-to-date National Weather Service (NWS) information—into “electronic flight bags” that integrate information with the aircraft avionics. Trajectory data is received separately by other aircraft avionics systems. Data communications between ground and flight crews will reduce bandwidth-heavy and workload-intensive voice communications, reduce the risk of miscommunication, and enable communications in areas where voice communications are currently unavailable.

Net-centric tools will provide law enforcement agencies, DOD, and DHS with increased situational awareness and decision-making support through a secure flow of collaborative information, creating a common picture of possible threats based on information from multiple sources. The situational awareness provided by net-centric operations and integrated surveillance systems will also pave the way for commercial, defense, and law enforcement use of UAS within the NAS, and help effectively meet the communication, surveillance, and operational needs when large numbers of UAS are introduced into the NAS.

#### **2.3.4 Airline Operations Centers / Flight Operations Centers (AOCs/FOCs)**

In 2025, NextGen will provide AOCs and FOCs with tools and information to support a flexible environment that will enable users to make strategic and tactical decisions based on their own business objectives and constraints. Strategic plans, developed by AOCs and FOCs in collaboration with ATC managers, involve a complex mix of time-varying uncertainties and competing business objectives. AOCs and FOCs must have complete knowledge of the impact of NAS constraints on their fleets and available mitigation options. As with controllers and pilots, there will be a distribution of responsibilities between ATC and AOCs/FOCs. NextGen shared situational awareness will be key to facilitating their collaboration.

Net-centric operations will facilitate data exchanges between air traffic facilities, security entities, aircraft, and the military. This will necessitate incentives for system users to ensure that the data they provide is accurate and timely, and that proprietary and classified data are secure and appropriately disseminated. Timely net-centric operations will improve the potential for security, defense, and law enforcement personnel to intercept a threatened flight before it gets underway, thus avoiding a costly and disruptive intervention.

Data communications will be used to direct re-routes tailored to the AOC and FOC preferences for flight priorities. These re-routes will take into consideration information available via the single authoritative weather source, changes in SAA, and other conditions supporting a flexible airspace environment. Developing the details of the roles and responsibilities associated with the AOC and FOC is one of the JPDO's current focus areas.

### 2.3.5 Airports



Airport airside operations encompass activities on an airport's runways, taxiways, aircraft parking aprons (whether adjacent to passenger terminals, cargo buildings, aircraft maintenance facilities, or GA facilities), and service roads. A major objective of NextGen is to enhance the safety and efficiency of aircraft and ground vehicle movements on the airport surface. In addition, NextGen's net-centric infrastructure and the resulting shared situational awareness promises to improve emergency response, enhance airfield maintenance activities, and improve asset and resource management for airport, airline, and third-party operators. It will also help reduce the impact of weather phenomena, such as fog, snow removal, and deicing.

A key objective of NextGen airside enhancements is to improve the efficiency of aircraft and ground vehicle movements in both airport movement areas (runways and taxiways) and non-movement areas (aircraft parking areas and the taxi lanes that serve them). NextGen's net-centric system architecture will provide both ATC and airport operations staff with real-time status information about runways, taxiways, navigational aids, and lighting systems. Ground service equipment movements will be monitored via cooperative (active transmitter) and non-cooperative (passive) surveillance in real time. Ground service equipment will be provided with the means to permit accurate navigation during low visibility conditions, maintain clearance from active runways and taxiways, and maintain safe separation from aircraft.

Airside resource management systems will provide guidance for scheduling, prioritizing, and actively managing deicing and anti-icing operations for both aircraft and airport surfaces during winter weather operations. Predictive weather capabilities, icing sensors, and continuously monitored deicing and anti-



icing holdover times will be used to adjust flight plans and maintain smooth flows of aircraft traffic on the ground and in the air. Integrated 4-D weather information will enable resources to align with operational demand to improve efficiency and reduce delays.

NextGen enhancements will affect a broad range of airport-related stakeholders, many of whom will need to invest in enabling technologies and capabilities to realize benefits. These stakeholders include airport operators, passenger and cargo airlines, other aircraft operators (i.e., military, business, and GA), fixed-base and corporate facility operators, and third-party ground service equipment operators. Proper consideration of the diverse interests and roles of these entities will be a key factor in successful NextGen implementation.

### **3. Challenges in Realizing 2025 Targeted Capabilities**

The targeted capabilities described in this document are dependent on the future success of NextGen partner agencies and stakeholders in addressing several major challenges. Many of these challenges are cross-cutting – that is, one or more capabilities are dependent on one or more of the challenges (Appendix C).

The JPDO conducted a risk assessment of the NextGen enterprise, based on assessments of hazards, probabilities of occurrence, and expected impacts. The assessment identified 10 significant challenges, which are discussed in the following sections. These challenges are organizational, technological, and political in nature, and they must be resolved in order to attain the 2025 capabilities. Paths to address most of them have been identified, and actions are being taken towards their resolution, however, additional clarification will be required in some areas.

The following section highlights each challenge, states why it will be difficult to achieve what is needed, and describes what is being done or should be done to overcome the challenge. A key JPDO contribution to the development of the 2025 system will be to ensure the continued progress on each one.

#### **3.1 Achieving Interagency Collaboration**

The challenges inherent in multi-agency programs are well known and could be significant. However, the benefits of involving the partner agencies in NextGen, each with their own area of responsibility and expertise, far outweigh these challenges. The targeted 2025 system description is based on the premise that the government partners will be successful in the execution of their individual responsibilities and that these agencies, teaming with the JPDO, will successfully integrate these activities into an optimally functioning NextGen operating environment.

The Senior Policy Committee (SPC), chaired by the Secretary of Transportation and consisting of the senior leadership of the partner departments and agencies, has, thus far, provided the leadership necessary to overcome the kinds of obstacles alluded to above. The JPDO supports the SPC by identifying issues and proposing strategies for their resolution. With the continued oversight, guidance, and support from the SPC, the premise above will become a reality.



### 3.2 Capacity, Delay, and Environment



NextGen is intended to increase throughput, reduce delays, and reduce aviation's impact on the environment, while maintaining safety and security. As aviation grows to meet the increasing demand for air travel and capacity is expanded, environmental impacts must be managed and reduced to avoid undue constraints on the NAS. NextGen technologies and Performance Based Navigation (PBN) will increase capacity and save time and fuel, decreasing aircraft emissions and improving the ability to mitigate aircraft noise.

A strategic Environmental Management System (EMS) will be used to integrate environmental and energy objectives into the planning, decision making, and operation of NextGen. Energy, emissions, and noise benefits will be realized from advanced systems and procedures. However, it will continue to be a challenge to balance aviation growth with commensurate environmental improvements. More improvements will be needed than can be operationally achieved. A major NextGen initiative, the Continuous Lower Energy, Emissions and Noise (CLEEN) program, helps accelerate the development and certification of promising new engine and airframe technologies and sustainable alternative fuels to deliver the greatest reductions in emissions, fuel burn, and noise.

There are interdependent relationships among aircraft environmental performance goals, meaning the pursuit of one goal, such as noise reduction, can affect progress toward another goal, such as reducing emissions. Performance attributes must be set at achievable levels and balanced for optimum benefits, weighing competing interests and goals. Setting goals too high invites cost overruns and risk of failure, while setting goals too low invites disappointment with the results and suboptimal return on investment. Balancing the conflicting goals of capacity and environment is necessary to manage controversy and conflict among various stakeholders and agencies of the Federal government.

The FAA has been working with the stakeholder community since the inception of NextGen to address these challenges. In addition, the JPDO will facilitate discussions to develop a set of integrated goals for 2025 to be used to align agencies' plans, research programs, and architectures. These goals will have to be periodically refined and validated to ensure that they are adequately ambitious, yet cost effective and achievable.

### 3.3 Airport and Airspace Security

Determining whether an aircraft that is demonstrating suspicious characteristics is a safety concern, criminal activity, or terrorism event requires the highest levels of cooperation and collaboration among owners/operators, FAA, DHS, DOD, and law enforcement authorities. If intervention is necessary, agencies must work together to track the aircraft for security, defense, and safety, using technologies that provide common situational awareness. Improving timely detection and response to such events in a coordinated, cost-effective manner will involve the application of integrated surveillance capabilities, secure information sharing, and informed risk analysis. The design, planning, and implementation of these capabilities require cooperation among the government partners to coordinate individual agency strategies and programs to achieve common objectives.



To address this challenge, government partners, through the JPDO Integrated Surveillance Governance Task Force and the more encompassing Air Domain Awareness Initiative sponsored by the National Security Staff, have agreed that DHS will lead the partner agencies in establishing and resourcing a robust, interagency technical support activity to conduct the engineering and development work needed to deliver NextGen integrated surveillance and related information-sharing capabilities.

### 3.4 Information Sharing



Targeted 2025 NextGen operations will require unprecedented information sharing among government agencies and NAS stakeholders, including information on safety, security, airport conditions, and flight and flow, as well as weather, surveillance, and aircraft operator data. At present, there is no common agreement on who will be responsible for developing, funding, implementing, and maintaining the NextGen information-sharing infrastructure. In addition, while there are industry-accepted standards and governance structures, there is no agreed-to governance structure for enabling and managing secure information exchange among NextGen stakeholders.

Moving from a legacy “need-to-know” paradigm to a NextGen, “need-to-share” information-exchange paradigm will require a major culture shift among stakeholders. This includes a shift from an agency- and organization-centric model to an enterprise-centric model, in which information services would freely, albeit securely, cross organizational boundaries. Existing information-sharing organizational structures, such as the Federal Chief Information Officer Council and the Program Manager for Information Sharing Environment, can be used to identify opportunities for sharing resources, improving collaboration, and developing solutions to support NextGen capabilities. Ultimately, as the agency responsible for NAS safety and efficiency, the FAA will have primary responsibility for ensuring implementation, maintenance, and interoperability of the core NextGen information-sharing infrastructure, either by direct acquisition or by coordination with partner agencies.

Mechanisms for secure information exchange, considering the varying sensitivity of the information involved, will be critical to enabling the net-centric operations needed for NextGen. Currently, information exchanges between agencies are primarily point-to-point, governed by rules and procedures documented in Memorandums of Agreement. In the NextGen environment, multi-lateral, ubiquitous information sharing will become the norm, rendering governance under these point-to-point agreements unmanageable. Adoption of federated information-sharing mechanisms would enable the agile, timely information exchanges needed for NextGen. During the development of these mechanisms, it will be necessary to identify classes of information that have information assurance or security implications, or that can be manipulated for competitive advantage, to ensure appropriate safeguards are implemented to prevent misuse of data.

The JPDO’s Net-Centric Operations Division has begun facilitating the partner agency engagement needed to address this challenge and deliver the required net-centric capabilities. The partner agencies will continue this collaboration, including resolution of the policy and governance questions noted above.

### **3.5 Research and Development, Verification and Validation, and Safety Certification for Complex Systems**

NextGen is a complex, interdependent system of systems, integrated to achieve the performance targeted for 2025. In the past, R&D of aviation-related tools and systems has focused on particular operational improvements, and did not always address how the individual elements would function together. To avoid unnecessary delay and expense, NextGen will require that R&D for the individual elements be coordinated in sufficient detail so that the fielded systems will operate together without the need for re-engineering.

Verification and validation (V&V), and the certification for complex systems, is a necessary part of NextGen development. In the future, these processes may be conducted for an integrated portfolio of projects rather than just as individual projects. Achieving this will require a significant change and greater team pre-implementation/pre-approval planning in the system approach to V&V. Structuring such an approach will require setting priorities and focused study.

To address this challenge, NextGen government partners have initiated detailed planning activities to identify and consider policy, training, and regulatory requirements as part of the process for transitioning R&D products to the implementing organization. Going forward, the NextGen government partners will work together to assure that shared and interoperating capabilities and technologies are acceptable to each participating agency and that they will perform reliably and safely end-to-end. To foster collaborative safety planning, the JPDO has initiated an interagency activity to develop a safety case and capability assessment methodology for TBO, which already has wide participation from all NextGen partner agencies and the private sector.

### **3.6 Balance of Human vs. Automation**

Current traffic separation standards and methodologies are largely driven by human cognitive limitations, impacting airspace sector size, routes, and traffic flows. Without sophisticated automation and a corresponding shift in roles and responsibilities, humans will remain a limiting factor for handling projected traffic levels. In addition, key NextGen features, such as translation of weather information into aviation constraints for decision aids, time-based metering, delegated separation, merging and spacing, UAS operations, and congestion management will be heavily reliant on automated functions. Therefore, it will be important to clearly define separation and spacing responsibility during delegated operations and the process for safe reversion to human control during automation failure, ensuring adequate backup.

These changes will impact both aircraft operators and controllers, raising significant policy issues, which must be resolved. These policy issues include:

- Workforce adjustments
- Consolidation and alignment of facilities
- Assuring an equivalent level of safety to performance by a human operator
- Coordination of investments in complementary ground and aircraft automation
- Shifts in liability

To address this complex dynamic, the JPDO is producing a detailed concept description of TBO, specifying system performance goals and metrics to serve as

a basis for an FAA- and NASA-led research plan to determine the optimal mix of automation and human input. This plan will aim to satisfy 2025 system performance requirements while building a foundation for an even more robust TBO capability beyond 2025.

### 3.7 Local Community Support

NextGen is an integrated program seeking to transform the NAS as the demand for air travel continues to grow. Airspace redesign will be needed to implement NextGen procedures that improve efficiency and flexibility. In addition, the construction of runways, gates, and related ground infrastructure will be needed at some airports to meet growing traffic levels. In the past, communities have sometimes used political and legal means to oppose airport expansion and airspace redesign. To successfully address community concerns, NextGen partners must acknowledge the issues to ensure that their community outreach and public relations efforts inform stakeholders and affected citizens of proposed NextGen implementation projects and their aviation, economic, and environmental implications. They must also take appropriate action to address the concerns. This will require making decisions and adopting policies that consider the needs of the community while achieving the best possible solution for serving both the local and national public interests.

### 3.8 Communication, Navigation, and Surveillance Backups



A central feature of NextGen is reliance on Global Navigation Satellite Systems (GNSS) for PNT services. Although GNSS are highly accurate and available, signal strength can be weak and susceptible to interference, potentially impacting a large number of aircraft during even localized disturbances. For these reasons, a cost-effective alternative position, navigation, and timing (APNT) system is needed to safely separate aircraft during GNSS service interruptions. Currently, existing ground-based navigation and surveillance systems serve as a backup for aircraft navigation and separation. However, these systems do not support NextGen data communications, ADS-B, or precision navigation technologies and the improvements they enable, nor is there a currently defined PNT backup that provides the same level of performance as GNSS.

Potential back-up solution strategies include considerations such as:

- Individual government agencies and the private-sector setting and satisfying their own requirements
- The Federal government providing a single APNT service requirement for all agencies and the private sector



- One designated Federal agency to provide essential back-up timing service only, allowing other agencies and the private sector to customize their position and navigation back-up solutions
- DOT and DHS working together to provide a single APNT service

As part of the National Implementation Plan, NextGen partners are currently developing recommendations for future alternative PNT solutions that address their specific requirements.

To determine the best approach, DOD and DOT led a working group that developed a national Position, Navigation, and Timing (PNT) architecture and implementation plan. The architecture promotes a “greater common denominator strategy” where the core needs of many users are efficiently met through externally provided, commonly available solutions, rather than by numerous, individually-customized systems. The overall plan to implement the strategy is to:

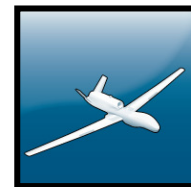
- Modernize GPS
- Prepare for divestment of projected, unnecessarily redundant GNSS-augmentation assets or services
- Identify, establish, and monitor levels of service provided by existing PNT systems

The *National PNT Architecture Implementation Plan* lays out the necessary near-term and executable tasks that must be implemented by agency partners to transition the current ad hoc architecture to a more capable PNT architecture.

### **3.9 Integration of Unmanned Aircraft Systems into the National Airspace System**

By 2025, it is expected that there will be significant demand and wide use in the NAS of both remotely piloted and autonomous UAS by commercial and security interests.

Rules governing operations for these aircraft will reflect the capabilities of the vehicle and the class of airspace in which they operate, just as is the case today for manned aircraft of varying equipage. NextGen will accommodate user and regulatory requirements to ensure that both national security and passenger safety are protected.



To accomplish this degree of integrated operations, several key issues will have to be successfully addressed. For regulatory purposes, it may be possible to treat UAS as another class of vehicle operating in the NAS, but safe and efficient introduction of remote and autonomous UAS operations will still require defining certification requirements and standards. This will include:

- End-to-end performance measures and thresholds
- Defining “pilot” roles and responsibilities
- Control station minimum functions
- Human factors and design standards
- Data link performance requirements, including safe operations in the event of communications link loss
- Safe operations in the event of GPS loss
- System safety unique to new applications of autonomy

The partner agencies are jointly developing an integrated Research, Development, and Demonstration (RD&D) Plan for UAS technology, which will address many of the issues raised above. Additionally, the partner agencies, led by the FAA, will jointly ensure that the results of this RD&D are implemented in a timely and systematic manner so NextGen effectively accommodates UAS to realize their full potential.

### **3.10 Achieving a Critical Mass of Equipped Aircraft**

To take full advantage of NextGen benefits, aircraft owners and operators will need to equip their aircraft with new avionics, such as ADS-B and data communications. However, this equipment may require substantial investment by industry and operators and long lead times to reach the marketplace. Moreover, some users are concerned that the necessary infrastructure, procedures, and operational capabilities that the government is providing may not be available in a timeframe that justifies early equipage investments. This is making some aircraft owners and operators reluctant to purchase and install the necessary equipment on their aircraft, and could potentially delay reaching a critical mass of NextGen-equipped aircraft.

To address this issue some of the options being considered are for the government to:

- Provide financial incentives to encourage equipage
- Help pay for the manufacturers’ non-recurring engineering development costs through operational evaluation projects
- Provide operational incentives to encourage equipage, such as “best-equipped, best-served,” giving priority in certain airspace to aircraft with advanced performance capabilities
- Mandate equipage

A combination of financial and operational incentives could also prove to be a viable option, and private investors may see a market opportunity to establish equipage lease options. It is expected that the equipage thresholds necessary to

achieve the targeted capabilities will be attained by a combination of some or all of the above while taking into account the operator's business case.

To address this challenge, the FAA and the JPDO have established a joint working group that is collaborating to determine the critical mass of aircraft that needs to be equipped, define the acceptable impact on non-equipped aircraft, and devise an implementation strategy. The RTCA NextGen Advisory Committee (NAC) is providing technical and business case information and recommendations to the FAA on near-term equipage requirements for all categories of civil users.

Depending on the results of the joint JPDO/FAA working group, it is likely that the RTCA will be asked to extend the scope of their activity to 2025 and beyond. NextGen government partners could assist this activity by developing equivalent equipage plans for their own agency-operated aircraft.

In any equipage policy involving segregation or sequencing of operations, the critical missions of DOD, DHS, and DOC will be recognized and accommodated.

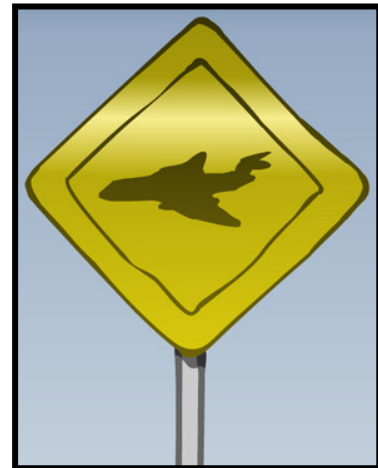
### 4. NextGen Benefits and Risks

To understand the benefits and risks associated with various levels of performance and technology options for the 2025 NextGen system, the JPDO has evaluated system alternatives representing seven levels of technological capability and complexity. Analysis to date indicates that the targeted capabilities described in this document achieve an appropriate balance of performance, cost, and risks, while assuming that critical R&D outcomes, policy issues, and challenges are successfully addressed.

The targeted benefits accrue from a variety of operational improvements enabled by the following:

- ADS-B In
- Data communications
- Automation
- Improved weather information
- Improved Trajectory Computation
- Net-centric operations and other features

Ultimately, these will enable the use of closely spaced parallel runways with separations down to 700 feet under IFR, merging and spacing tools that improve



predictability of traffic flow, improved traffic flow management, reduced separation standards to improve the use of airspace, trajectory planning and flexible routing that reduce the likelihood of weather-induced delay. They will also provide enhanced situational awareness for pilots, which will include improved knowledge of their location on the airport surface and runway incursion alerting.

A major effect of these improvements is to reduce delay and increase throughput, or to achieve some combinations of these – all of which will benefit users of the system. Other effects include enhanced safety and reduced variability in system performance between good and bad weather days, which will enhance schedule predictability. The extent to which the NextGen 2025 will affect throughput and delay will depend, in part, on how users choose to employ its capabilities.

To illustrate the benefits of the advanced technologies embodied in NextGen 2025, the JPDO's analysis is based on FAA-forecasted traffic levels and anticipated airline scheduling. The results present the top-level benefits in terms of increased throughput and reduced delay compared to the capabilities that will result from the March 2011 NGIP. Compared to the NGIP, NextGen 2025 capabilities would reduce system-wide delays caused by air traffic management by 46 million minutes, or nearly 60 percent, while accommodating the increased throughput.

Careful management of development is needed to ensure a cost-effective implementation. The risk of cost overruns is a major consideration for NextGen planning. The JPDO reviewed previous advanced technology efforts to indicate the potential development and implementation risks for NextGen. A study of 145 FAA, NASA, and DOD programs showed an average cost growth of 46 percent, with a large range of variability among individual programs (73 percent standard deviation). The large average cost growth indicates the potential risks faced by technology-intensive programs. However, the variation in cost growth indicates that this risk is avoidable. The JPDO's coordination between the NextGen partner agencies and industry stakeholders is one means of mitigating this risk.

## **5. Closing Comments**

The targeted system capabilities for 2025 described in this report are promising and, when implemented, will provide the nation with a significantly improved air traffic management system. Although these capabilities do not encompass the full NextGen vision, they offer a realistic, implementable system that is consistent with the expected demand and available resources, and provide the path to implementing the full NextGen vision in and beyond the 2025 timeframe. Considered in this broader scope, this is the right 2025 system for the nation, which offers an appropriate measured step toward the NextGen vision.

## Targeted NextGen Capabilities for 2025

Implementation will be challenging, however, with the right leadership and dedication these challenges are surmountable.

As champions of the NextGen vision, the JPDO will use the 2025 definition to advocate for activities that are needed to ensure that the most advanced and beneficial system is available to support the nation's economic growth, environmental goals, and homeland security needs by 2025. The JPDO will continue to work with its government partners to advance innovations that will be needed beyond 2025, in accordance with the ultimate vision for NextGen.

## Appendix A: Targeted Operational Improvements for 2025

OIs	Title	DESCRIPTION
OI-0322	<b>Low-Visibility Surface Operations</b>	Aircraft and ground vehicle movement on airports in low visibility conditions is guided by accurate location information and moving map displays. Aircraft and ground vehicles determine their position on an airport from Global Positioning System (GPS), Wide Area Augmentation System (WAAS), Local Area Augmentation System (LAAS), via ADS-B and Ground-Based Transceivers (GBT) systems with or without surface based surveillance. Location information of aircraft and vehicles on the airport surface is displayed on moving maps using Cockpit Display of Traffic Information (CDTI) or aided by Enhanced Flight Vision Systems (EFVS), Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS) or other types of advanced vision or virtual vision technology.
OI-0331	<b>Improved Arrival/ Surface/ Departure Flow Management</b>	This Operational Improvement (OI) integrates advanced Arrival/Departure flow management with advanced Surface operation functions to improve overall airport capacity and efficiency. Air Navigation Service Provider (ANSP) automation uses arrival and departure-scheduling tools and four dimensional trajectory (4DT) agreements to flow traffic at high-density airports. This includes the integration of departure scheduling from multiple airports into the overhead stream, the assignment of arrival and departure runways to maximize the use of available runways at an airport, and runway configuration management with airspace configuration management to optimize the use of surface and airspace capacity when changing a runway configuration. Automation incorporates Traffic Management Initiatives (TMIs), current and forecasted conditions (e.g., weather), airport configuration, user provided gate assignments, requested runway, aircraft wake characteristics, and flight performance profiles. ANSP, flight planners, and airport operators monitor airport operational efficiency and make collaborative real-time adjustments to schedules and sequencing of aircraft to optimize throughput. Arrival and departure flows and surface operations are more effectively planned and managed through the integration of current flight plans as well as real-time airborne and surface trajectory information into Air Navigation Service Provider (ANSP) decision support automation tools. These decision support tools enable ANSP flow managers to work collaboratively with flight operators and with ANSP controllers to effectively manage high-capacity arrival and departure flows in the presence of various weather conditions. Automation provides optimal departure scheduling and staging and arrival sequencing based on aircraft wake and airborne performance characteristics.
OI-0360	<b>Automated Support for Trajectory Negotiation</b>	Trajectory management is enhanced by automated assistance to negotiate pilot trajectory change requests with properly equipped aircraft operators. Local and national objectives for flow management are fully integrated within decision-support systems. Automated congestion resolution with probabilistic demand and capacity forecast (based on 4-DT) supports incremental flow decisions plus en route conflict resolution.
OI-0402	<b>Single Runway Departure Wake Mitigation</b>	Single Runway Departure Wake Mitigation will provide increased departure capacity from single runways by reducing longitudinal wake separation standards under certain crosswind conditions. Airport weather sensors and products will be used to monitor crosswind conditions, and air traffic automation systems will be used to indicate to controllers when they can safely reduce wake separation standards, increasing departure capacity.
OI-0403	<b>Single Runway Arrival Wake Mitigation</b>	Single Runway Arrival Wake Mitigation will provide increased arrival capacity to single runways by reducing longitudinal wake separation standards for Instrument Flight Rules (IFR) operations under certain crosswind conditions. Weather sensors and products will be used to monitor crosswind conditions, and air traffic automation systems will be used to indicate to controllers when they can safely reduce wake separation standards, increasing arrival capacity.



## Targeted NextGen Capabilities for 2025

OIs	Title	DESCRIPTION
OI-0406	<b>NAS Wide Sector Demand Prediction and Resource Planning</b>	Trajectory management is enhanced by automated assistance to negotiate pilot trajectory change requests with properly equipped aircraft operators. Local and national objectives for flow management are fully integrated within decision-support systems. Automated congestion resolution with probabilistic demand and capacity forecast (based on 4-DT) supports incremental flow decisions plus en route conflict resolution.
OI-0408	<b>Full Flight Plan Constraint Evaluation with Feedback</b>	Provides automation to automation negotiation. Constraint information that impacts proposed flight routes is incorporated into ANSP automation, and is available to users for their pre-departure flight planning.
OI-0409	<b>Remotely Staffed Tower Services</b>	Remotely Staffed Towers for operations into and out of designated airports, physically located somewhere other than at the airport but still controlled by a tower controller, without physically constructing, equipping, or sustaining tower facilities at these airports.
OI-2022	<b>Net-Enabled Common Weather Information – Level 3 NextGen</b>	This improvement provides the full capability that supports the NextGen ConOps to assimilate weather in decision making for all area of operations, and completes the replacement of today's patchwork of conflicting sources of weather observations and forecasts.
OI-0326	<b>Airborne Merging and Spacing – Single Runway</b>	Arriving or departing aircraft to/from single runways are instructed to achieve and maintain a given spacing in time or distance from a designated lead aircraft as defined by an Air Navigation Service Provider (ANSP) clearance. Onboard displays and automation support the aircraft conducting the merging and spacing procedure to enable accurate adherence to the required spacing. Flight crews are responsible for maintaining safe and efficient spacing from the lead aircraft. Responsibility for separation remains with the ANSP. Assigned spacing may include a gap to allow for an intervening departure between subsequent arrivals. Mixed-equipage operations are supported; a spacing-capable aircraft can perform airborne spacing behind a non-capable aircraft as long as it is transmitting cooperative surveillance information. This Operational Improvement (OI) includes multiple streams merging to a single runway and includes development of ANSP capability and procedures.
OI-0327	<b>Full Surface Traffic Management with Conformance Monitoring</b>	Equipped aircraft and ground vehicles provide surface traffic information in real-time, to all parties of interest, the use of improved surveillance, automation, on-board displays, and data link of taxi instructions.
OI-0306	<b>Provide Interactive Flight Planning from Anywhere</b>	Individual flight-specific trajectory changes resulting from Traffic Management Initiatives (TMIs) will be disseminated to the appropriate ANSP automation for tactical approval and execution. Automated congestion resolution tools for specific situations (departure, en route congestion).
OI-0333 e/f	<b>Improved Operations to Closely Spaced Parallel Runways</b>	These improvements allow additional reduction of lateral spacing for arrivals (0333e) and departures (0333f). Visual Conditions-like capacity may be achieved with the integration of new aircraft technologies such as ADS-B In, allowing descents below 1200 ft to do paired dependent arrivals to runways with greater than 700 ft separation.
OI-0338	<b>Efficient Metroplex Merging and Spacing</b>	ANSP automation and decision-support tools incorporate aircraft wake characteristics and forecast wake transport conditions. Spacing buffers between streams approaching and departing multiple metroplex runways are reduced to allow efficient airborne merging and spacing, increasing greater traffic throughput and reduced ANSP workload in terminal areas.

## Targeted NextGen Capabilities for 2025

OIs	Title	DESCRIPTION
OI-0340	<b>Near-Zero-Visibility Surface Situation to Pilots, Service Providers and Vehicle Operators</b>	Aircraft and surface vehicle positions are displayed to aircraft, vehicle operators, and air navigation service providers (ANSP) to provide situational awareness in restricted visibility conditions, increasing efficiency of surface movement. Surface movement is guided by technology such as moving map displays, enhanced vision sensors, synthetic vision systems, Ground Support Equipment and a Cooperative Surveillance System. Aircraft and surface vehicle position will be sensed and communicated utilizing systems such as Cockpit Display of Traffic Information (CDTI) and Automatic Dependent Surveillance-Broadcast (ADS-B). Efficient management of surface movement requires cooperative surveillance (i.e., ADS-B out) for all aircraft and ground vehicles present.
OI-0343	<b>Reduced Separation – HD En Route, 3-mile</b>	ANSP provides reduced and more efficient separation between aircraft where the required performance criteria are met, regardless of location other than operations in oceanic airspace. Advances in ANSP surveillance (e.g., ADS-B) and automation allow lower separation minimums to be used in larger areas of the airspace. This reduces the incidence of conflicts and increases the efficiency of the conflict resolution maneuvers.
OI-0350	<b>Flexible Routing</b>	Leveraging enhanced flight capabilities based on RNP, flight operators can operate along preferred and dynamic flight trajectories based on an optimized and economical route for a specific flight, accommodating user-preferred flight trajectories. ANSP uses ground-based decision-support tools to maintain separation responsibility for aircraft. This OI optimizes available airspace, allowing flight operators more flexible routings to reduce block time and fuel burn.
OI-0354	<b>Reduced Oceanic Separation and Enhanced Procedures</b>	Longitudinal and lateral spacing between aircraft conducting oceanic pair-wise altitude change maneuvers is reduced to 10 miles, with ground-based separation responsibility. Horizontal spacing between aircraft conducting oceanic, pair-wise co-altitude maneuvers, such as passing a similar-speed aircraft, is reduced to below 30 miles, with ground-based separation responsibility.
OI-0355	<b>Delegated Responsibility for Horizontal Separation: Terminal</b>	Known as delegated interval management with wake risk mitigation. Under this procedure, aircraft performing delegated separation procedures are paired and separate themselves from one another by maintaining a given time or distance from a designated aircraft using cockpit-based tools.
OI-0356	<b>Delegated Separation – Pair-Wise Maneuvers</b>	The ANSP delegates separation responsibility for specific pair-wise maneuvers to capable aircraft for the purposes of improving operator routing, enhancing operational efficiency, or increasing ANSP productivity. The use of this procedure will replace some of the ATC vectoring and speed instructions made necessary by existing surveillance.
OI-0381	<b>Ground Based Augmentation System (GBAS) Precision Approaches</b>	GPS/GBAS support precision approaches to Category I and eventually Category II/III minimums, for properly equipped runways and aircraft. GBAS can support approach minimums at airports with fewer restrictions to surface movement, and offers the potential for curved precision approaches. GBAS may also support high-integrity surface movement requirements.
OI-0384	<b>Improve Runway Safety Situational Awareness for Pilots</b>	Runway safety operations are improved by providing pilots with improved awareness of their location on the airport surface as well as runway incursion alerting capabilities. A surface moving map display with ownship position will be available and both ground-based (e.g., RWSL) and cockpit-based runway incursion alerting capabilities will also be available to alert pilots when it's unsafe to enter the runway. Moved to NGOps-4 because it requires sophisticated ADS-B In applications.

## Appendix B: Operational Improvements Expected Beyond 2025

OIs	Title	DESCRIPTION
OI-0348	<b>Reduce Separation - High Density Terminal, Less Than 3-miles</b>	Increases metroplex airspace capacity and supports super density airport operations. Enhanced surveillance and data processing provides faster update rates to allow reduced separation. Arrival/departure routes with lower RNP values (e.g., RNP<1 nm) are defined with less than 3 miles lateral separation between routes, subject to wake vortex constraints, enabling the use of more routes in a given airspace.
OI-0359	<b>Self-Separation Airspace – Oceanic</b>	Aircraft are managed by the ANSP until cleared for self-separation operations. Once cleared aircraft fly preferred optimum profiles without coordination with ANSP. Aircraft-to-aircraft separation is delegated to the flight deck in designated airspace for capable aircraft with ADS-B and onboard conflict detection and alerting. The separation minima are reduced to a level that maintains appropriate margins of safety.
OI-0360	<b>Automated Support for Trajectory Negotiation</b>	Full 4-DT with negotiation and automation critical to negotiation and with supporting controller in loop separation. A trajectory change can be requested by a UAS operator, FOC personnel or flight deck. The trajectory change would then be relayed to the pilot/aircraft operator over a safety critical link.
OI-0366	<b>Dynamic Airspace Performance Designation</b>	A dynamic change in airspace access is executed by providing real-time airspace performance designation information and requirements to airspace users, whether preflight or during airborne operations. Temporary Flight Restrictions and Special Use Airspace use is factored into the dynamic airspace performance designation process. A change to airspace performance designation may be routine or made dynamically in response to forecast demand.
OI-0385	<b>Full Collaborative Decision Making</b>	User automation automatically supports/negotiates “tactical” reroutes to deal with NAS constraints including strategic separation or schedule. Timely, effective, and informed decision-making based on shared situational awareness is achieved through advanced communication and information sharing.
OI-0387	<b>Dynamic, Pairwise Wake Turbulence Separation</b>	Wake turbulence separation applications for departure, arrival, and en route are integrated into air traffic automation to provide real time dynamic, pairwise, lateral, longitudinal, and vertical separation requirements for trajectory management based on aircraft and weather conditions.
OI-0410	<b>Automated Virtual Towers</b>	The automation (no controller) provides a variety of services from sequencing and basic airport information to limited separation management. IFR throughput (in both Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC)) is increased by using both ground and air surveillance systems and by exploiting available aircraft capabilities.
OI-2024	<b>Full Integration of Weather Information into NAS Automation and Decision Making</b>	The automation forecasts and plans airspace configurations that account for fleet mix and performance-based gains to match capacity to demand, as well as incorporating controller workload models (instead of MAP values). NAS automation tools directly utilize weather information (including uncertainty), demand information, and other capacity constraints to analyze the integrated information picture. The results of this analysis allows users and service providers to select from among proposed, automation-developed mitigation strategies to balance demand to available capacity, both strategically and tactically.

## Targeted NextGen Capabilities for 2025

OIs	Title	DESCRIPTION
OI-0337	<b>Closely-Spaced Routes</b>	High density En Route static flow corridors accommodate aircraft that are capable of self-separation, equipped with ADS-B and onboard conflict detection and alerting, traveling on similar routes, achieving high traffic throughput by minimizing complexity and crossing traffic. When there are large numbers of suitably equipped aircraft traveling in the same direction on similar routes, the ANSP may implement flow corridors, which consist of long tubes or "bundles" of parallel lanes. (This is a modification of flow corridors to permit controllers to be responsible for separation.)
OI-0339	<b>Integrated Arrival Departure and Surface Traffic Management for Metroplex</b>	Metroplex trajectory management assigns each arriving aircraft to an appropriate runway, arrival stream, and place in sequence. Departing aircraft are assigned an appropriate runway and a departure time based on efficient merging and spacing with aircraft departing other metroplex terminals, as well as those already in overhead streams. Surface scheduling automation integrates arriving and departing aircraft and provides runway/taxi movement to optimize surface movement.
OI-0341	<b>Limited Simultaneous Runway Occupancy</b>	This OI is not intended to permit simultaneous aircraft operations on the runway, but rather to permit an aircraft to start or end a maneuver while another aircraft is completing a maneuver; only one aircraft may be conducting an actual operation, take off or landing, while the other aircraft is either exiting the runway or getting in position to perform an operation - may require ADS-B in/out for surveillance and pilot situational awareness.
OI-0362	<b>Self-Separation Airspace Operations</b>	In self-separation airspace, capable aircraft, equipped with ADS- B and onboard conflict detection and alerting, are responsible for separating themselves from one another, and the ANSP provides no separation services, enabling preferred operator routing with increased ANSP productivity. This is not part of ground based alternative.
OI-0363	<b>Delegated Separation – Complex Procedures</b>	This Operational Improvement involves more complex delegated separation responsibilities than those performed using a cockpit display to cross, merge, or pass another aircraft. Using advanced airborne technologies with conflict detection and alerting, aircraft in ANSP-managed En Route and transition airspace are delegated separation responsibilities to perform more complex operations, possibly maintaining separation from more than one other aircraft.
OI-0365	<b>Advanced Management of Special Activity Airspace</b>	Access to airspace is enhanced through more advanced automated real-time scheduling and dynamic status updates of SAA. This facilitates daily negotiations between the ANSP and military operators to determine an effective strategy that meets military operational requirements while minimizing the impact on traffic flows.
OI-0368	<b>Flow Corridors – Level 2 Dynamic</b>	High density En Route dynamic flow corridors accommodate aircraft that are capable of self-separation, equipped with ADS- B and onboard conflict detection and alerting, traveling on similar wind-efficient routes or through airspace restricted by convective weather cells, SAA, or overall congestion. These corridors are defined daily and shifted throughout the flight day to avoid severe weather regions and airspace restrictions (e.g., SAA) or take advantage of favorable winds.
OI-0369	<b>Automated Negotiation/Separation Management</b>	High density En Route dynamic flow corridors accommodate aircraft that are capable of self-separation, equipped with ADS- B and onboard conflict detection and alerting, traveling on similar wind-efficient routes or through airspace restricted by convective weather cells, SAA, or overall congestion. Real-time information on corridor location, and logistics and procedures for dynamically relocating a corridor while it is in effect must be developed.
OI-0370	<b>Trajectory-Based Management – Gate-To-Gate</b>	Automation forecasts and plans airspace configurations that account for fleet mix and performance-based gains to match capacity to demand. All aircraft operating in high density airspace are managed by 4-DT in En Route climb, cruise, descent, and airport surface phases of flight to dramatically reduce the uncertainty of an aircraft's future flight path in terms of predicted spatial position (latitude, longitude, and altitude) and times along points in its path.

## Appendix C: NextGen Capabilities' Dependencies on Policy and Safety Challenges

A check "✓" indicates that the challenge if unmitigated may impact a specific capability  <b>Impacted Target 2025 Capabilities</b>	Policy and Safety Challenge									
	Achieving the Benefits of Interagency Collaboration	Capacity, Delay, and Environment	Airport and Airspace Security	Information Sharing	R&D, V&V, and Safety	Human versus Automation	Local Community Support	CNS Backup	UAS Integration	Achieving a Critical Mass of Equipped Aircraft
Net-Centric Operations	✓		✓	✓	✓	✓			✓	
Trajectory Based Operations	✓	✓		✓	✓	✓		✓	✓	✓
DataComm		✓	✓	✓	✓	✓		✓	✓	✓
Improved Surface Operations		✓		✓				✓		✓
Airspace Redesign	✓	✓					✓	✓	✓	
RNAV/RNP		✓					✓	✓		✓
ADS-B	✓	✓	✓		✓				✓	✓
CATM	✓	✓		✓	✓	✓				✓
On-Demand NAS Information	✓			✓						
Time-Based Flow Management		✓			✓	✓		✓		✓
Separation Management	✓	✓			✓	✓		✓	✓	✓
Merging and Spacing	✓	✓			✓	✓		✓	✓	✓
UAS Operations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
GPS	✓	✓						✓		
Reduced Weather Impact	✓	✓		✓	✓	✓			✓	✓
Layered Adaptive Security	✓		✓	✓						

## **Appendix D: Supporting Documents**

Joint Planning and Development Office, "Concept of Operations for the Next Generation Air Transportation System, Version 3.2," JPE.JPDO.gov, September 2010

Joint Planning and Development Office, "Integrated Work Plan for the Next Generation Air Transportation System FY13," JPE.JPDO.gov, 2010

Joint Planning and Development Office, "Preliminary Safety Risk Assessment of NGOps 4," Version 2.0, October 2011

Joint Planning and Development Office, "Next Generation Air Transportation System Enterprise Architecture FY13," JPE.JPDO.gov, October 2010

Joint Planning and Development Office, "Next Generation Air Transportation System Integrated Plan, Version 1.0," JPDO.gov, December 2004

Federal Aviation Administration, "FAA's NextGen Implementation Plan," March 2011

MITRE Paper # MP100121, "Documentation of Model Input Parameters for NextGen, Trade Space Analyses," September 2010

RAND Corporation Report, "Is Weapons Systems Cost Growth of Increasing," 2007

US Department of Transportation AV-2005-061, "Status of FAA's Major Acquisitions: Cost Growth and Schedule Delays Continue to Stall Air Traffic Modernization," 2005

The Aerospace Corporation, "Perspectives on NASA Mission Cost and Schedule Performance Trends," Presentation at Goddard Space Flight Center Symposium, 2008

Congressional Budget Office (CBO) Study, "A Budgetary Analysis of NASA's New Vision for Space Exploration," 2004

Government Accountability Office, GAO-04-642, "NASA Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management," 2004

Government Accountability Office (GAO), GAO-06-368, "Major Weapon Systems Continue to Experience Cost and Schedule Problems under DOD's Revised Policy," 2006

Government Accountability Office, GAO-09-326SP, "Assessments of Selected Weapon Programs," 2009



## Appendix E: Critical Research

Target 2025 Flight Segment	IWP ID	Research Name
Flight Planning	R-0130	Applied Research on Automation-Assisted Collaboration Capabilities
	R-0580	Applied Research for Initial Probabilistic Weather Forecasts
	R-1120	Applied Research on Automated Flight and Flow Evaluation and Resolution Capabilities
	R-2112	Applied Research on Weather Integration into NextGen Decision Making
	R-2156	Applied Research on the Flow-Based Trajectory Management Concept
Push Back and Taxi	R-0350	Applied Research on Air and Ground-Based Runway Incursion Detection Technologies
	R-0630	Applied Research on Effective Surface Management in Various Weather Conditions
	R-2160	Ground-Based Surface Conflict Detection and Resolution Algorithm
Takeoff and Departure	R-0350	Applied Research on Air and Ground-Based Runway Incursion Detection Technologies
	R-0370	Applied Research on Advanced Scheduling Concepts in Congested Terminal Airspace
Domestic and Oceanic Cruise	R-0660	Applied Research on Integrating NextGen Information into an Automated Environment
	R-1580	Applied Research on an Airborne Collision Avoidance Systems
	R-2160	Ground-Based Surface Conflict Detection and Resolution Algorithm
Descent and Approach	R-0930	Applied Research on Low Visibility Independent Parallel and Converging Approach Procedures
	R-1240	Applied Research on Low Visibility Dependent Multiple Approach Procedures
Enabling Research Supporting All Flight Segments	R-0530	Applied Research on Automated Air and Ground Separation Management Alternatives
	R-1080	Applied Research on the Service Benefits and Costs for NextGen Aircraft Capabilities
	R-1520	Applied Research on the Role of Human Forecasters and Automated Systems

## Appendix F: Glossary

**Air Navigation Service Provider (ANSP)** – ANSP refers to the organization, personnel, and automation that provide separation assurance, traffic management, infrastructure management, aviation information, navigation, landing, airspace management, or aviation assistance services for airspace users.

**Air Traffic Control (ATC)** – A service provided for the purpose of preventing collisions between aircraft and on the maneuvering area between aircraft and obstructions, and for expediting and maintaining an orderly flow of air traffic.

**Air Traffic Flow Management (ATFM)** – The dynamic, integrated management of air traffic and airspace – safely, economically, and efficiency – through the provision of facilities and seamless services in collaboration with all parties.

**Airline Operations Centers (AOC)** – An AOC co-locates representatives from numerous departments in the airline to manage the operational control of each flight in the schedule, in compliance with company procedures and regulatory requirements.

**Area Navigation (RNAV)** – A method of navigation that permits aircraft operation of any desired flight path within the coverage of station-referenced navigation aids, the limits of the capability of self-contained aids, or a combination of these.

**Automatic Dependent Surveillance-Broadcast (ADS-B) In/Out** – A surveillance system in which an aircraft or vehicle to be detected is fitted with cooperative equipment in the form of a data link transmitter. The aircraft or vehicle periodically broadcasts its GPS-derived position and other information such as velocity over the data link, which is received by a ground-based transmitter/receiver (transceiver) for processing and display at an air traffic control facility. The ADS-B Out portion is the broadcast of the position. The ADS-B In portion provides the Out broadcast of position information to other aircraft and vehicles that are equipped with ADS-B In.

**Concept of Operations (ConOps)** – The NextGen ConOps provides an overall integrated view of NextGen operations in the end-state. It describes how the envisioned capabilities will operate in 2025 and represents the transformations necessary to achieve the overall goals of NextGen.

**Data Communications (DataComm)** – DataComm represents a key transformation of communications, moving from the current voice system to a predominately digital textual mode of communication. DataComm will enable more efficient operations, faster revised clearances, trajectory-based routing, optimized profile descents, and automation of routine tasks to improve controller and flight crew productivity. DataComm will reduce communication errors, taxi time, fuel use and greenhouse gas emissions, ground delays and operational costs.

**En Route Automation Modernization (ERAM)** – ERAM replaces the En Route HOST and back-up system at the 20 FAA Air Route Traffic Control Center. ERAM will increase capacity and air traffic flow, and improve NAS efficiency by increasing automated navigation and improving conflict detection services, as well as enable flexible routing around congestion, weather, and other restrictions.

**Enterprise Architecture (EA)** – The EA is a technical document that describes the segments, capabilities, operational activities, and identified relationships to the key target components of NextGen in the year 2025. It is intended to be used as a tool for planning, negotiating, and understanding the processes and technical solutions that impact the aviation community.

**Flight Management System (FMS)** – The FMS is a computer system that uses a large database to allow routes to be preprogrammed and fed into the system by means of a data loader. The system is constantly updated with respect to position accuracy by reference to conventional navigation aids. The sophisticated program and its associated data base ensure that the most appropriate aids are automatically selected during the information update cycle.

**Flight Operations Center (FOC)** – FOCs support airline hub operations and is generally responsible for the day-to-day operation of departures, pilot training, pilot standards, technical support, pilot staffing, and scheduling and quality assurance/compliance functions.

**Geospatial Information System (GIS)** – GIS is a collection system that captures, stores, analyzes, manages, and presents data with reference to geographic location information. GIS merges cartography, statistical analysis, and database technology to provide information about any object, natural or man-made, that can be referenced to the earth.

**Global Navigation Satellite Services (GNSS)** – The GNSS constellation provides space-based positioning, velocity, and time.

**Global Positioning System (GPS)** – A space-base radio positioning, navigation, and time-transfer system. The system provides highly accurate position and velocity information, and precise time, on a continuous global basis, to an unlimited number of properly equipped users. The system is unaffected by earth weather, and provides a worldwide common grid reference system. The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to the user. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into three-dimensional position, velocity, and time. System accuracy for civil users is normally 100 meters horizontally.

**Instrument Flight Rules (IFR)** – A set of rules governing the conduct of flight under instrument meteorological conditions.

**Instrument Landing System (ILS)** – A ground-based precision approach system that provides course and vertical guidance to landing aircraft.

**Integrated Work Plan (IWP)** – A foundational document that describes when NextGen capabilities and potential improvements will be introduced and who will be responsible for them.

**Interval Management (IM)** – A flight deck-based capability using ADS-B In that off-loads controller workload by shifting tactical vectoring to allow aircraft to implement traffic spacing strategies for the controller. For properly equipped aircraft pairs (with ADS-B Out and ADS-B In) in addition to issuing an IM instruction to the flight crew, the controller may also delegate separation as part of that procedure. This procedure is referred to as IM with Del Sep.

**National Airspace System (NAS)** – The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas.

**Net-Centric Operations (NCO)** – The decision support and other applications using net-enabled information for information transfer and retrieval. Net-enabled information is an information network that makes information available, securable, and usable in real time to distribute decision making. Information may be pushed to known users and is available to be pulled by other users, including users perhaps not previously identified as having a need for the information.

**Required Navigation Performance (RNP)** – RNP is a statement of the navigation performance accuracy necessary for operation within a defined airspace. RNP operations introduce the requirement for on-board navigational performance monitoring and alerting.

**System Wide Information Management (SWIM)** – SWIM provides for NAS-wide transport and sharing of information between the FAA systems and all NextGen users. It is a uniform single point of entry for all Communities of Interest to publish and subscribe to NAS services and data.

**Traffic Flow Management (TFM)** – TFM provides the means to maintain efficient flow of aircraft and use of airspace based on capacity and demand.

**Trajectory-based Operations (TBO)** – The use of four-dimensional trajectories as the basis for planning and executing all flight operations supported by the air navigation service provider.

**Special Activity Airspace (SAA)** – Any airspace with defined dimensions within the National Airspace System where limitations may be imposed upon aircraft operations. This airspace may be restricted areas, prohibited areas, military operations areas, ATC assigned airspace, and any other designated airspace areas. The dimensions of this

airspace are programmed into User Request Evaluation Tool (URET) and can be designated as either active or inactive by screen entry. Aircraft trajectories are constantly tested against the dimensions of active areas and alerts issued to the applicable sectors when violations are predicted.

**Unmanned Aircraft System (UAS)** – An aircraft that is flown without a pilot-in-command onboard and is either remotely or fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous.

**Vertical Takeoff and Landing (VTOL)** – Aircraft capable of vertical climbs and/or descents and of using very short runways or small areas for takeoff and landings. These aircraft include, but are not limited to, helicopters.